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The Response of Aviation Training Costs to Changes in the Requirement for Aviators

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Summary

In June 1996, the Naval Center for Cost Analysis (NCCA) began a study called 'Cost of a Sailor.' The primary purpose of that continuing effort is to develop and maintain a capability for estimating the total cost impact on the Navy—direct and indirect—occasioned by changes in the number of operating force personnel. The study's products are intended to inform both acquisition and force structure decisions.[1] Results of the first phase of the work were distributed in [1]. More recent results are in [2]. CNA has contributed to the effort since its inception, designing the overall study methodology and conducting the initial statistical analysis [3].

Estimation of direct personnel costs poses few difficulties. This is not the case, however, for indirect costs. In developing estimates of the latter, the study is using the historical *Future Years Defense Program* (FYDP) as its primary database.[2] The analytical approach consists of first assembling annual data on recruiting, training, health care, base operations, and other personnel support activities. The data are compiled at the program element (PE) level of detail for a successive series of years. Next, using statistical regression analysis, we estimate the *change* in the levels of those activities (as measured in terms of numbers of officers, numbers of enlistees, and funding for operation and maintenance) that has resulted from a change in the number of persons requiring support. The slope coefficients in the regression

1. Decisions in the acquisition community frequently center on tradeoffs between people—enlisted crew members of ships, in particular—and labor-saving technology. The primary motivation for this study was a perception in that community that personnel costs tend to be understated. In considering force structure options such as early retirement of ships or sizing carrier air wings, it is equally important that both direct and indirect personnel costs be taken into account.

2. Data for years not yet included in the historical FYDP were extracted from the Navy's programming database known as WINPAT.

functions then become the factors used to construct our estimates of *variable* indirect costs. For example, we estimated that for a change of 100 enlistees in the operating forces, there has been a change of 30 enlistees in initial and general-skill training combined. For purposes of cost estimation, that empirical relationship is extended into the future.

Until now, the one support area—and a fairly significant one—that has not been addressed is post-commission training for the principal officer communities. The reason is that, with one exception, manpower and Operation and Maintenance, Navy (O&MN) data for those activities are simply not visible in the FYDP's PE structure. The exception is aviator training, for which there are several distinct PEs with associated data that are directly amenable to the analytic approach described above. Recently, the decision was made to proceed with the aviator training cost estimation and document it in this paper, and to find an interim means of dealing with the other communities.

For reasons that we will explain later, we are focusing on generic aviator training. What this means is that we make no cost distinction among strike pilots, maritime pilots, rotary pilots, and navigators/naval flight officers. We are also limiting the analysis to training at the undergraduate level. Aviator training beyond that level (primarily in readiness squadrons) is considered a direct cost of fleet operations and not a personnel cost. We have taken the number of operational Navy aviators reported in the FYDP as the driver—the determinant—of the contemporaneous level of aviator training activity. (We looked for statistical evidence of lags in the adjustment process and found none.) We have accounted for the joint occurrence of Navy and Marine Corps aviator training in our results. The final estimate of the change in annual training costs associated with a change of one operational aviator is $72 thousand (FY 1997 dollars). The Military Personnel, Navy (MPN) component of that is $40 thousand; the O&MN component is $32 thousand. The MPN estimate, which includes all categories of compensation for students, instructors, and enlisted support, also provides for other forms of indirect support required by those personnel. In accordance with the overall study guidance, we have not tried to incorporate procurement costs (of training aircraft, for instance) into the estimate.

Concepts of training costs

If an analyst were asked to develop a generalized list of training cost elements, it would probably resemble the following:

- Transportation to and from the training site
- Student housing and subsistence
- Student pay and allowances
- Instructor pay and allowances
- Supplies and materials
- Imputed charges for facilities and equipment
- Program management and administration.

This is an entirely satisfactory list, beneath which lies a concept of training—and its associated costs—as a one-time occurrence in which a person acquires and demonstrates a set of skills, thereby achieving qualification in a particular occupational specialty. In the present context, one frequently hears statements such as, "It costs a million dollars to train a pilot." Putting aside the extremely important question of how that (or any other) cost magnitude was determined, this concept of training costs has obvious value for persons who develop training policy and manage personnel resources. However, when acquisition and force structure decisions are being considered, the pertinent cost question is, "How will costs vary with the different alternatives in the decision set?" With specific reference to aviator training, the question is, "How will costs in the training establishment change in response to specified increases or decreases in the requirement for aviators?" This is closely akin to the economist's notion of *marginal* cost, but here it is the marginal training cost of an operational aviator, not the marginal cost of a new trainee, that is at issue.

In this paper, we will explain how the study has attempted to answer this last question. Note, however, that for reasons just stated, the results of this analysis are not likely to be of great use to the training community. This is especially true in light of the fact that the FYDP data used here, while suitable as a base for estimating indirect operating and support costs of ships, aircraft, and weapons, are almost certainly too coarse to serve decision-making needs within the training establishment.

Development of training cost data

Aviator training activity is organized and reported in the FYDP under four program elements:

- 0804742N Undergraduate Navigator/NFO Training (UNT)
- 0804745N Undergraduate Pilot Training (UPT) - Strike
- 0804746N Undergraduate Pilot Training (UPT) - Maritime
- 0804747N Undergraduate Pilot Training (UPT) - Rotary

There is a fifth PE, 0804743N, which covers other naval aviation training, but we excluded it from the analysis for two reasons. The first is that very few officers are associated with it, and the second is that activities within it have changed over time.

As suggested in the summary, we combined the four PEs to create a generic aviator training cost database. One reason for doing so is that had we estimated four sets of costs, the noise in the data would almost certainly have masked any true differences in costs. Another is that we were not confident that the available data would permit us to cleanly identify four separate sets of determinants of aviator training activity. And last, we thought that users of these results might often have information on the total number of operational aviators under consideration, but not have a breakdown by specialty.

We assembled the data for a 16-year period beginning in FY 1981 and ending in FY 1996. Historical FYDP data extend further back in time, but certain inconsistencies in the earlier data are clearly apparent.[3] Because of the integration of Navy and Marine Corps aviator training, we recorded (but kept separate) the numbers of USN and USMC officers in each PE. There are substantial numbers of Navy enlistees

3. In fact, as the table in appendix A reveals, there are inconsistencies in some of the data after 1981.

involved, which we also included in the database. The number of Marine Corps enlistees is negligible.

A few comments are in order concerning the nature and interpretation of all FYDP data on officers and enlistees used in the study. First, those data reflect manning levels at year-end. Although the statistical correlation between manning levels (counts) and numbers of authorized billets is extremely high, the two are not the same. Billets are typically thought of as representing validated *requirements*, whereas manning levels represent the personnel system's attempt to satisfy those requirements. Because this is an empirical analysis, we consider it an advantage that the manning data reflect the realities of the system's behavior. However, we are interpreting those counts as the conceptual, or functional, equivalent of billets in the following sense: If the system were in strict equilibrium, the counts would remain unchanged although different people would be entering and leaving the various PEs. In addition, we interpret year-to-year changes in the manning levels to represent changes in requirements, except for whatever random noise may be in the data.

The remaining cost component is operation and maintenance. In the FYDP, O&MN data are reported in current dollars. This means that they include year-to-year price variability. To be meaningfully analyzed, those data need to be converted to a constant price base. We used the composite O&MN escalation index, published in [4], for that purpose. All the manpower and constant-dollar O&MN data are displayed in appendix A. That appendix also shows the year-by-year numbers of operational aviators that served as the driver, or more precisely, the *predictor variable* in the first regression. Appendix B identifies the 25 PEs included in the compilation of data on operational aviators.[4] All those PEs are within FYDP Program 2, General Purpose Forces, meaning that the predictor variable includes only those aviators associated with fleet operations.

4. All but one of those PEs have specific type/model/series aircraft associated with them. The exception, 0204112N, includes only ship's company for the fleet's aircraft carriers. However, a number of carrier billets have aviator designators. We examined the manning document for the CVN-68 and found that 23 percent of the officer billets call for aviators. Accordingly, our data on operational aviators include 23 percent of the officers in that PE.

Statistical analysis and results

Regression for officers in training PEs

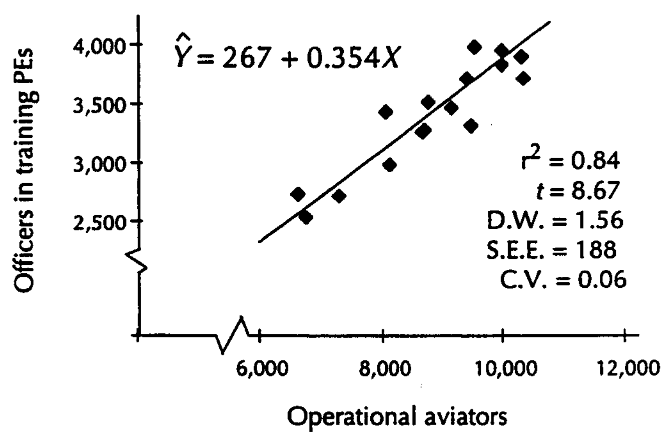
The central piece of the analysis leading to the eventual cost estimate is the relationship between changes in the total number of naval officers in aviator training PEs, the dependent variable, and changes in the number of operational aviators. The dependent variable includes student, instructor, and maintenance and administrative officers. Figure 1 is a scatter plot showing the relationship over the 16-year period spanned by our data. The figure also shows the regression equation that was estimated by ordinary least squares, as well as the regression summary statistics: r^2, *t* ratio, Durbin-Watson (D.W.), standard error of estimate (S.E.E.), and coefficient of variation (C.V.). The scatter suggests that the relationship is decidedly linear, at least over the observable range of the variables, and we note that the summary statistics are better than adequate.[5]

The slope coefficient in the regression equation, 0.354, is the critical parameter estimate in these results. Its interpretation is that for a change of 100 operational aviators, there has been a change of 35.4 officers in aviator training PEs. Three characteristics of this result are important to consider. First, it is a statistical estimate and, as such, is

5. The r^2 value of 0.84 indicates that 84 percent of the variability in the dependent variable is explained by the regression. For the *t* ratio, which tests the statistical significance of the regression, a conventional threshold value is 2.0. The value here of 8.67 connotes a very high degree of significance, meaning that the observed relationship is almost certainly not due to chance alone. The D.W. statistic is used in testing for a systematic pattern in the regression errors, which are presumed to be random. The value of 1.56 above, while somewhat below the ideal value of 2.0, is nevertheless well within the "safe" range. Finally, a C.V. of 0.06 indicates that the S.E.E., which captures the size of a typical error, is equal to 6 percent of the mean of the dependent variable.

subject to error (uncertainty). An approximate 90-percent confidence interval for the true parameter is 0.28 to 0.43. Second, its value represents a complex interaction of factors that include attrition, career progression, and sea-shore rotation. In other words, even with no change in the number of operational aviators, there are annual flows into and out of the training pipeline to accommodate those factors. A change in operational requirements perturbs the system in ways whose combined effects are reflected in the statistical estimate obtained here, but whose individual effects cannot be ascertained. Finally, what we have is strictly an empirical relationship. It represents how the system *has* behaved, not *should* behave.

Figure 1. Regression results: officers in aviator training PEs, FY 1981–1996



Before proceeding to the next phase of the analysis, we undertook one excursion. It seems plausible that training activity might not adjust immediately—meaning in the same year—to changes in the requirement for aviators. We investigated that issue statistically. First, we looked at a regression with the predictor variable lagged one year. That formulation has the dependent variable in year t related to operational aviators in t-1. The results from this were not as good as the earlier ones.[6] Next, we examined the so-called partial adjustment

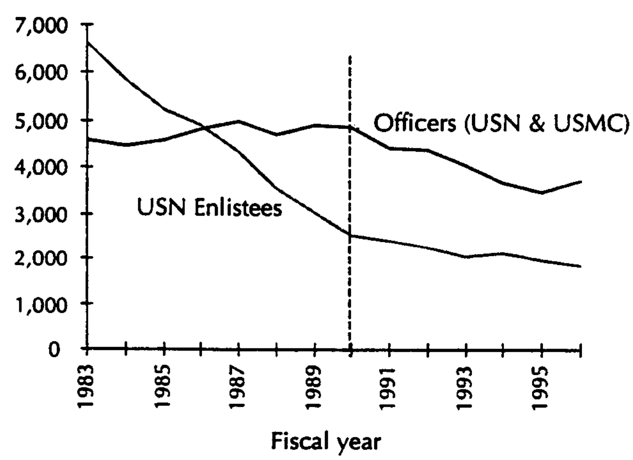
6. The r^2 and t ratio were lower and the S.E.E. and C.V. higher.

model, which proved successful in similar work done earlier at CNA [5, 6]. That model has the original predictor variable, operational aviators, plus a lagged value of the dependent variable on the right-hand side. The results here were no better than the original ones, and they had an intuitively unreasonable feature—a negative coefficient on the lagged dependent variable. We therefore adopted the original results without change.

Enlistees in aviator training PEs

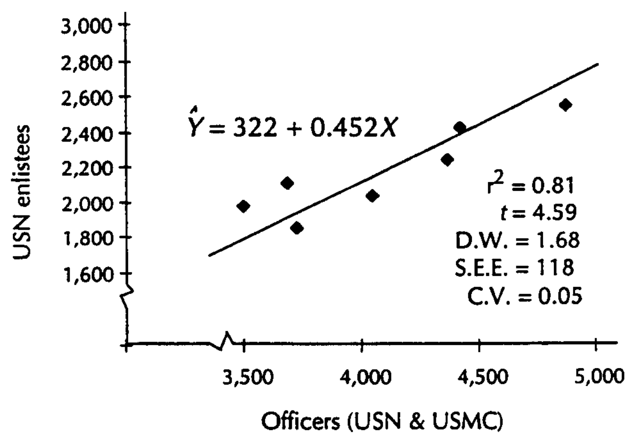
As noted earlier, substantial numbers of U.S. Navy enlistees provide support to the joint training of Navy and Marine Corps aviators. Figure 2 is a graph of those numbers over time, both enlistees and the sum of USN and USMC officers. The graph begins in FY 1983 because that was the first year of consistent reporting of Marine Corps officers associated with aviator training.

Figure 2. Enlistees and USN and USMC officers in aviator training PEs



The graph makes it clear that the numbers of enlistees changed in the 1980s in ways that were unrelated to changes in the numbers of officers. A large part of that had to do with substitution of contract maintenance of aircraft for maintenance that was formerly done by military personnel. In addition, there were similar substitutions involving activities other than aircraft maintenance. Our interpretation of the information at hand is that beginning in 1990—the dashed line in the graph—the continued drawdown in enlistees corresponded to reductions in the number of officers. We therefore estimated the regression function for the period, 1990 through 1996. Those results are in figure 3.

Figure 3. Enlistee regression results, FY 1990–1996



As with the officer regression, the key result here is the slope coefficient, 0.452. The previous discussion regarding interpretation of the estimate and its associated summary statistics is equally applicable here.

Operation and maintenance costs in training

The final component of aviator training costs is O&MN, roughly three-fourths of which appear to be attributable to flight operations.[7]

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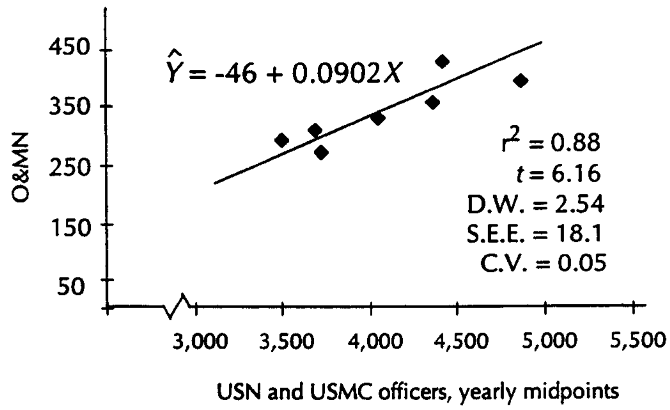
7. This estimate was obtained by combining training flight-hour data from O&MN budget justifications with flight-hour cost data from the Navy's Visibility and Management of Operating and Support Costs (VAMOSC) Air system.

Because this category of costs was also affected by the substitutions mentioned in the discussion of enlisted personnel, we have developed the regression for the same seven-year period, 1990 through 1996, used for enlistees. Results are in figure 4.

Figure 4. O&MN regression results, FY 1990–1996 (FY 1997 dollars in millions)



As with the enlistee regression, the predictor variable here is the sum of Navy and Marine Corps officers because O&MN money supports training activity for both. One change, however, is that we defined that variable as an average, or midpoint, of beginning-of-year and end-of-year manning levels. Because the O&MN variable is a flow of funds over each year, we thought it could be more accurately explained by a measure of the representative number of officers present throughout the year. Because the costs here are in millions of dollars, the interpretation of the slope coefficient, 0.0902, is that for a change of one officer; the change in O&MN costs has been \$90.2 thousand (1997 dollars). Ideally, we would have used a two-stage process in which we first estimated change in flight activity associated with change in officers, and then estimated change in O&MN associated with change in flight activity. However, the absence of time series data on training flight hours meant we had to link officers directly with O&MN costs. The summary statistics suggest that this relationship is slightly better than the enlistee regression results.

Synthesis of results

We now have all the results needed to assemble the final cost estimate. That estimate, which represents the total annual training cost associated with a change of one operational aviator, is developed in table 1: We will explain the entries in the table row by row.

Table 1. Synthesis of results (FY 1997 dollars in thousands)

	Factor	x	Oth support	x	Officer factor	x	CSR[a]	=	Cost
Officer	0.354		1.111		—		81.2		31.9
Enlistee	0.452		1.457		0.354		35.9		8.4
							MPN subtotal		**40.3**
O&MN	90.2		—		0.354		—		**31.9**
							Total		**72.2**

a. Weighted-average composite standard rate.

In estimating the officer MPN cost, the starting point is the slope coefficient, 0.354, from the officer regression in figure 1. That number is multiplied first by an other-support factor, 1.111, which was generated earlier in the 'Cost of a Sailor' study. This factor represents the other categories of personnel support required by all naval officers associated with aviator training. That product is then multiplied by a compensation measure, $81.2 thousand, which is an average Navy composite standard rate (CSR), weighted by the number of officers in each pay grade in FY 1997.[8] The result, $31.9 thousand, is an estimate of the officer-related MPN training cost.

8. The weighted-average CSR corresponds to a grade level that is midway between O-3 and O-4. That is probably higher than the average grade in aviator training, but no explicit provision has been made for flight pay. In our opinion, those differences are offsetting.

The enlisted MPN estimate closely parallels the estimate for officers. The slope coefficient, 0.452, comes from figure 3. The factor for other indirect support, 1.457, also generated through 'Cost of a Sailor,' is driven by initial and general-skill training for enlistees. The product of those two numbers is then multiplied by the officer factor. The explanation for this is that the enlisted slope coefficient is associated with a change of one officer in training PEs, but the change here has been only 0.354 officers. The enlisted MPN estimate is completed by applying the CSR factor of $35.9 thousand, also a weighted average.

Estimating the remaining piece, O&MN, is straightforward. The coefficient of $90.2 thousand was interpreted earlier. That number is reduced by the fractional officer factor to obtain the $31.9 thousand shown in the table. To recap, the MPN and O&MN sum of $72.2 thousand is our estimate of the annually recurring training-cost impact of a unit change in the Navy's requirement for operational aviators.

Concluding remarks

We noted at the outset that the 'Cost of a Sailor' study is to be a continuing effort. Shortly after this paper is distributed, NCCA will bring on line an information system called COMET—Cost-of-Manpower Estimating Tools. All the study's analytical results to date, including those reported here, will be consolidated in that system. COMET will also include additional cost information obtained from other sources. As further data and sharper insights become available, that information will be reworked and no doubt strengthened. In the interim, however, the study's current products can reliably serve a broad spectrum of users.

Appendix A: Aviator training cost database

Table 2. Aviator training cost database

Fiscal year	Operational aviators	USN training officers	USMC training officers	Total training officers	USN training enlistees	O&MN (thousands of FY97$)
1981	8,079	3,433	92	3,525	6,458	—
1982	8,699	3,264	64	3,328	6,627	—
1983	8,775	3,522	1,072	4,594	6,629	322,579.3
1984	9,184	3,465	989	4,454	5,874	276,177.7
1985	9,436	3,725	878	4,603	5,245	307,211.1
1986	9,573	3,987	842	4,829	4,928	379,273.4
1987	10,011	3,952	1,026	4,978	4,348	356,978.0
1988	10,361	3,711	999	4,710	3,576	386,366.4
1989	10,328	3,894	1,005	4,899	3,035	394,753.2
1990	10,007	3,835	1,039	4,874	2,546	377,912.4
1991	9,498	3,315	1,103	4,418	2,426	401,843.2
1992	8,719	3,287	1,081	4,368	2,239	349,467.0
1993	8,139	2,987	1,062	4,049	2,041	319,047.5
1994	7,312	2,725	963	3,688	2,114	302,924.9
1995	6,778	2,537	963	3,500	1,977	291,234.6
1996	6,620	2,726	1,000	3,726	1,859	268,016.4

Appendix B: Program elements with operational aviators

Table 3. Program elements with operational aviators

Number	Program element title
0201117N	Airborne command post (CINCEUR)
0201118N	Airborne command post (CINPAC)
0201120N	Airborne command post (CINCLANT)
0204112N	Multipurpose aircraft carriers
0204134N	A-6 squadrons
0204135N	A-7 squadrons
0204136N	F/A-18 squadrons
0204142N	F-4 squadrons
0204144N	F-14 squadrons
0204151N	COD squadrons
0204152N	E-2 squadrons
0204153N	Reconnaissance squadrons
0204154N	Sea-based electronic warfare squadrons
0204155N	Shore-based electronic warfare squadrons
0204156N	Readiness squadrons
0204233N	SH-3/SH-60F squadrons
0204234N	S-3 squadrons
0204243N	Light-airborne multipurpose system (LAMPS)
0204251N	ASW patrol squadrons
0204262N	Readiness squadrons
0204303N	Air mine countermeasures squadrons
0204453N	Direct support squadrons
0204571N	Consolidated training systems development
0208015N	Combat developments
0208024N	F/A-18 combat development squadrons

References

[1] Naval Center for Cost Analysis, *Preliminary Results of Phase I of the 'True Cost of a Sailor Study,'* Serial NCCA-21/323-96, Oct 1996

[2] Office of the Assistant Secretary of the Navy (Research, Development and Acquisition), *Manpower Cost Estimating Databases and Methodologies,* Memorandum for the Distribution List, Aug 1997

[3] Henry L. Eskew. *'True Cost of a Sailor Study': Methodology and Preliminary Results,* Sep 1996 (CNA Annotated Briefing 96-83)

[4] Naval Center for Cost Analysis, *Inflation Indices and Outlay Profile Factors,* Mar 1997

[5] Samuel D. Kleinman. *Some Evidence of How the Navy's Manpower Ashore Varies with Manpower at Sea,* Jul 1991 (CNA Research Memorandum 91-104)

[6] Henry L. Eskew. *Some New Estimates of the Navy's Indirect Manning Costs,* Dec 1995 (CNA Research Memorandum 95-203)

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